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Green Bond Market Development and Fiscal Sustainability in the EU: Drivers of Market Entry and Depth

Radosveta Krasteva-Hristova ^{1,*}  and Vanya Georgieva ² ¹ Department of Accounting, Tsenov Academy of Economics, 5250 Svishtov, Bulgaria² Faculty of Economics, Agricultural University-Plovdiv, 4000 Plovdiv, Bulgaria; v.georgieva@au-plovdiv.bg

* Correspondence: r.krasteva@uni-svishtov.bg

Abstract

Green bond markets have expanded rapidly across the European Union, but development remains uneven across Member States. Using a balanced EU-27 panel for 2021–2025, this study distinguishes sovereign market entry from the depth of the overall green debt market. Pooled Probit and Tobit estimates show that larger economies are substantially more likely to issue sovereign green bonds, whereas government debt and the budget balance are not significantly associated with entry. Market depth is positively associated with economic scale and a stronger budget balance, although the latter relationship partly overlaps with institutional quality. Environmental taxation is not significantly associated with market depth, providing no evidence of substitution for green debt financing. The findings support measures to lower entry costs and strengthen institutional capacity in smaller Member States.

Keywords: green bonds; sovereign debt; fiscal sustainability; environmental taxes; green finance; EU-27; Probit; Tobit; capital markets; green transition

1. Introduction

The European Union's green transition requires investment on a scale that public budgets alone cannot provide. The European Green Deal itself stresses the need to mobilise both public and private financial resources in order to meet the Union's climate objectives ([European Commission, 2019](#)). Green bonds are debt securities whose proceeds are earmarked for environmental and climate projects, thereby combining market-based financing with the targeted allocation of capital to sustainable investment ([Fatica et al., 2021](#); [Flammer, 2021](#)). They are therefore one of the principal instruments for channelling private capital into the green transition.

Europe is the leading region worldwide for green bond issuance ([Climate Bonds Initiative, 2026](#)). This position rests on a clearly defined policy and regulatory framework, including the European Green Deal, the EU Taxonomy for sustainable activities and the European Green Bond Standard. Together, these initiatives seek to improve transparency and comparability and to reduce the risk of greenwashing ([European Commission, 2019](#); [European Parliament & Council of the European Union, 2020, 2023](#)).

The market is expanding rapidly. By April 2026, the outstanding amount of green debt securities issued by EU-27 residents approached EUR 1.3 trillion—more than four times its level five years earlier—according to the authors' calculations based on European Central Bank data ([ECB, 2026](#)). The market now spans sovereign, bank and corporate issuers.



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This aggregate success, however, conceals a considerable imbalance. A comparatively small group of Member States accounts for the greater part of outstanding green debt. In the most developed national markets, outstanding green debt securities exceed 10% of gross domestic product (authors' calculations based on [ECB, 2026](#); [Eurostat, 2026e](#)). At the same time, the participation of several Member States remains very limited, while some countries still lack a meaningful green debt market. Approximately half of the Member States have never issued a sovereign green bond. The central question is therefore no longer whether green bonds matter for financing the green transition—they clearly do—but why some countries participate actively while others remain at the periphery of the market.

Against this background, the study poses three research questions:

RQ1. Which factors are associated with the participation of EU Member States in the sovereign green bond market?

RQ2. Which factors are associated with the depth of national green debt markets in the European Union?

RQ3. Is there a negative relationship between environmental taxation and green debt market depth, as might be expected if the two instruments serve as substitutes?

To answer these questions, the paper distinguishes two dimensions of market development. The first is entry into the sovereign green bond market, measured by the presence of outstanding sovereign green debt. The second is the depth of the overall green debt market, measured by total outstanding green debt issued by resident sectors as a percentage of GDP. The empirical analysis uses a balanced panel covering all 27 Member States for the period 2021–2025, compiled from ECB securities issues statistics and Eurostat macroeconomic, fiscal, financial and environmental data. Sovereign market entry is analysed with a pooled Probit model, and market depth with a pooled Tobit model that accounts for observations with no outstanding green debt. The econometric analysis is complemented by monthly descriptive data for the period from December 2020 to April 2026.

The results indicate that the two dimensions of market development are associated with different factors. Sovereign participation is linked primarily to economic size, whereas government debt and the budget balance show no statistically significant association with market entry. Market depth is positively associated with economic size and a stronger budget balance, although this fiscal relationship partly overlaps with broader institutional quality and issuer credibility. Environmental taxation is not significantly related to market depth, providing no evidence that it substitutes for green debt financing.

The paper makes three main contributions. First, it distinguishes sovereign market entry from the depth of the overall market and shows that the two dimensions are associated with different conditions. Second, it clarifies the relationship between green finance and fiscal sustainability by treating the fiscal position not only as a stand-alone factor but also as part of broader issuer credibility. Third, it examines the relationship between environmental taxation and green debt financing—two important green policy instruments whose interaction remains comparatively little studied in the EU context.

The study thereby extends research on the role of risk, uncertainty and issuer characteristics in green debt markets ([Aharon et al., 2025](#); [Mertzanis & Tebourbi, 2025](#); [Wang et al., 2024](#)) to differences in market entry and depth within the common EU regulatory environment.

The remainder of the paper is organised as follows. Section 2 presents the literature review and formulates the hypotheses. Section 3 describes the data, the variables and the empirical strategy. Section 4 presents the descriptive and econometric results, including the heterogeneity and robustness analyses. Section 5 discusses the results and their implications for EU policy and for smaller Member States. Section 6 concludes.

2. Literature Review and Hypotheses

2.1. Green Bonds and Sustainable Finance in the EU

Green bonds are debt instruments based on the earmarked use of proceeds, whereby the capital raised is allocated to projects pursuing environmental, climate-related, or broader sustainability objectives. Their distinguishing feature does not lie in a repayment mechanism different from that of conventional bonds, but rather in the issuer's commitment to use the proceeds for predefined green activities and to disclose information regarding their allocation and expected impact. In this respect, green bonds are regarded as a market-based mechanism that connects demand for sustainable investment assets with the need to finance the transition towards a low-carbon economy (Flammer, 2021; Tang & Zhang, 2020).

Within the European Union, this instrument has developed in a particularly strong institutional environment. The European Green Deal places the transition towards climate neutrality at the centre of the Union's economic strategy and emphasises the need to mobilise substantial private and public investment (European Commission, 2019). It was followed by the development of a more comprehensive sustainable finance framework, including Regulation (EU) 2019/2088 on sustainability-related disclosures in the financial services sector, Regulation (EU) 2020/852 establishing the EU Taxonomy for sustainable activities, and Regulation (EU) 2023/2631 on European Green Bonds (European Parliament & Council of the European Union, 2019, 2020, 2023). These legislative acts share a common objective: to enhance the transparency, comparability, and credibility of sustainable financial products and to reduce the risk of merely formal or self-declared "green" financing.

The EU Taxonomy is particularly important for the green bond market because it provides a common classification framework for identifying economic activities that may be regarded as environmentally sustainable. It establishes a logic according to which a sustainable activity must make a substantial contribution to one or more environmental objectives, must not cause significant harm to the remaining objectives, and must comply with minimum social safeguards (European Parliament & Council of the European Union, 2020). The European Green Bond Standard builds upon this framework by establishing a voluntary but harmonised designation for bonds whose proceeds are aligned with the EU Taxonomy and are accompanied by requirements concerning pre-issuance information, post-issuance reporting, and external review (European Parliament & Council of the European Union, 2023).

The academic literature examines green bonds both as financing instruments and as signals to investors. From the issuers' perspective, green bonds may broaden the investor base, demonstrate a commitment to sustainability, and improve access to capital markets. Empirical evidence indicates that markets frequently respond positively to green bond issuance, with observable effects on issuers' market valuation, institutional ownership, and stock liquidity (Tang & Zhang, 2020). Among corporate issuers, green bond issuance may also be associated with subsequent improvements in environmental performance and a stronger commitment to climate-related objectives (Flammer, 2021).

At the same time, the literature does not unconditionally support the proposition that a green label automatically reduces financing costs. Evidence concerning the so-called "greenium" remains mixed and depends on issuer characteristics, sector, liquidity, bond type, and the quality of the information disclosed. Zerbib (2019) identifies a small negative yield spread for green bonds relative to comparable conventional bonds, whereas Wulandari et al. (2018) demonstrate that liquidity risk also affects green bond yields. Fatica et al. (2021) find a pricing advantage for green bonds issued by supranational institutions and non-financial corporations, but not for those issued by financial institutions. They also emphasise the importance of external review and repeated access to the green bond market.

These findings draw attention to trust as a key prerequisite for market development. Investors cannot independently and fully monitor whether the proceeds from each issuance are actually used to finance environmentally meaningful projects. External reviews, certification, allocation reports, and impact reports therefore reduce information asymmetry and the risk of greenwashing. [Hyun et al. \(2020\)](#) demonstrate that a higher degree of green credibility, including external certification, may be reflected in more favourable bond-pricing conditions. In the European context, this function has gradually become institutionalised through the requirements governing external reviewers and disclosures under the European Green Bond Standard.

Recent studies show that sustainable debt markets respond to both the broader risk environment and issuer-specific conditions. Using transaction-level data for 73 countries, [Mertzanis and Tebourbi \(2025\)](#) find nonlinear and delayed links between geopolitical risk and green bond issuance. [Aharon et al. \(2025\)](#) identify time-varying connectedness between climate policy uncertainty, green bonds, and equity markets, while [Wang et al. \(2024\)](#) show that transition attributes and issuer characteristics affect the pricing of China's low-carbon transition bonds. The present study extends this literature by examining economic scale, fiscal conditions, and institutional capacity within the common EU regulatory framework.

Beyond regulation, green bond market development also depends on macroeconomic and institutional conditions. Economic size, capital-market maturity, institutional quality, and national climate commitments influence countries' capacity to develop green debt financing ([Tolliver et al., 2020](#)). This is especially relevant in the EU, where common rules coexist with substantial national differences in scale, liquidity, administrative capacity, and issuance experience.

Green bonds should therefore be viewed as part of a broader sustainable-finance architecture rather than merely as a distinct financial product. Common rules can improve transparency, but effective market participation still depends on credible frameworks, eligible projects, reporting capacity, and investor confidence. These differences justify the distinction between market entry and market depth developed below.

2.2. Sovereign Green Bonds, Market Access and Fiscal Capacity

Sovereign green bonds represent a specific application of green debt instruments in which the state acts as the issuer and the proceeds are allocated to public expenditure or investment with environmental and climate-related objectives. Unlike corporate green bonds, where the issuance decision is primarily associated with the investment strategy and capital structure of an individual enterprise, a sovereign green bond issuance forms part of the broader framework of public debt management. It must be integrated into the annual borrowing programme, the maturity structure of government debt, the investor-base strategy, and the country's overall fiscal framework. Consequently, the decision to enter the sovereign green bond market cannot be explained solely by the need to finance green projects.

The literature emphasises that green bond market development depends on a combination of macroeconomic, institutional, and market-related factors. [Tolliver et al. \(2020\)](#) demonstrate that macroeconomic conditions, capital market development, institutional quality, and national climate commitments are important drivers of green bond market growth. In the context of the European Union, [Dan and Tiron-Tudor \(2021\)](#) similarly find that green bond issuance is associated with countries' economic, governance, and financial characteristics, indicating that market participation is not merely a function of environmental financing needs. These findings are particularly relevant to the present study because they suggest that Member States with larger economies and more developed financial markets are better positioned to access green debt financing.

Sovereign green bond issuance requires a minimum effective scale. An issuer must have a sufficiently large and predictable borrowing programme to structure the green bond as a recognisable and liquid financial instrument. Institutional investors generally prefer issues of sufficient size, supported by a clearly established yield curve and opportunities for secondary-market trading. Small countries, particularly those with limited annual financing requirements and relatively narrow domestic government securities markets, may experience difficulties in providing such liquidity. In this respect, market entry is associated not only with fiscal financing needs but also with the depth and organisation of the sovereign debt market itself.

In addition to market scale, sovereign green bond issuance requires administrative and project-development capacity. The state must prepare a green bond framework, identify eligible green expenditure, ensure the traceability of proceeds, produce allocation and impact reports, and arrange for external review. The European Green Bond Standard reinforces this logic by introducing requirements concerning Taxonomy alignment, pre-issuance information, post-issuance reporting, and the involvement of external reviewers, including specific provisions applicable to sovereign issuers (European Parliament & Council of the European Union, 2023). Such requirements strengthen investor confidence but also create fixed costs associated with the preparation and maintenance of the issuance framework.

The importance of confidence and institutional quality is also confirmed by studies examining the role of external verification and issuer characteristics. Bachelet et al. (2019) demonstrate that green bond premia and liquidity depend on the type of issuer and the presence of a third party certifying the green characteristics of the issue. Gianfrate and Peri (2019) find that green bonds may provide financial advantages to issuers, but that these benefits are associated with the market's assessment of the quality and credibility of the instrument. For sovereign issuers, therefore, the green label is not sufficient in itself. It must be supported by a credible institutional framework, transparency, and the capacity to provide regular reporting.

Sovereign green bonds may also perform a catalytic role in the broader sustainable debt market. Cheng et al. (2024) demonstrate that a sovereign green bond debut may stimulate subsequent growth in corporate green bond issuance, improve market liquidity, and promote the use of external verification. This implies that sovereign market entry may serve both as a signal and as an infrastructural benchmark for other issuers. A sovereign green bond creates a reference asset, establishes reporting practices, and may enhance the legitimacy of the market among institutional investors. This catalytic role, however, presupposes that the state itself possesses sufficient capacity to act as a credible initial issuer.

The European context presents an additional distinctive feature. A common regulatory framework does not eliminate national differences in administrative preparedness, the availability of eligible green expenditure, or the maturity of sovereign debt markets. The Recovery and Resilience Facility requires national recovery and resilience plans to incorporate measures related to the green transition and to align them with the broader priorities of the European Union (European Parliament & Council of the European Union, 2021d). This creates a foundation for public green investment, but it does not automatically ensure readiness for market-based financing through sovereign green bonds. Effective issuance requires coordination among budgetary planning, project selection, public debt management, and investor communication.

It follows that small economies may remain outside the market not because they lack a need for green financing or do not support the climate transition, but because their relative market-entry costs are higher. A limited borrowing programme, a smaller portfolio of eligible projects, lower market liquidity, and more restricted administrative resources may make an independent sovereign green bond issuance more difficult. This is consistent with

the broader understanding that green bonds affect not only the source of financing but also the manner in which issuers organise their sustainability strategies, reporting processes, and engagement with investors (Maltais & Nykvist, 2021; Monk & Perkins, 2020).

Accordingly, the present study assumes that entry into the sovereign green bond market is primarily a function of economic scale, institutional preparedness, and market infrastructure rather than a direct consequence of the current fiscal position. Fiscal stability may influence the volume and sustainability of subsequent market development, but initial participation requires a minimum effective scale and sufficient administrative capacity. On this basis, the first hypothesis is formulated as follows:

H1. *Economic scale is positively associated with participation in the sovereign green bond market, whereas the current fiscal position has no significant independent association with participation.*

2.3. Fiscal Sustainability and Green Bond Market Depth

Fiscal sustainability is a key prerequisite for the development of any sovereign debt market, including its green segment. In broad terms, it refers to the government's ability to service its current and future obligations without requiring abrupt fiscal policy adjustments or losing access to market financing. The classical literature examines fiscal sustainability through the response of budgetary policy to debt accumulation. An improvement in the primary balance as the level of public debt increases signals corrective fiscal action and, consequently, greater fiscal sustainability (Bohn, 1998). This logic is particularly important in the European context, where Member States operate within an environment characterised by common fiscal rules, market discipline, and considerable investor sensitivity to sovereign debt indicators.

Green bonds do not alter the fundamental nature of sovereign financing. They remain debt instruments and are therefore assessed through the same principal channels that apply to conventional government bonds: issuer creditworthiness, debt sustainability, fiscal position, liquidity, the yield curve, and institutional confidence. The green label may broaden the investor base and enhance the issuer's visibility among sustainability-oriented investors, but it does not eliminate the assessment of sovereign risk. Empirical studies of the euro-area sovereign debt crisis demonstrate that the market pricing of sovereign risk responds both to fiscal fundamentals and to changes in market expectations and contagion risk (Arghyrou & Kontonikas, 2012; Beirne & Fratzscher, 2013; De Grauwe & Ji, 2013).

From this perspective, it is important to distinguish between two separate decisions. The first concerns whether a country enters the sovereign green bond market at all. The second concerns whether, following market entry, it succeeds in developing a deep and sustainable green debt market. The first decision may depend more strongly on minimum effective scale, administrative preparedness, and the availability of eligible green expenditure. The second is more closely related to fiscal credibility because market depth requires more than a one-off issuance. It implies the capacity to provide bonds regularly, maintain consistent reporting practices, and preserve investor confidence over time.

High public debt and weak fiscal positions may restrict precisely this capacity for market deepening. They increase perceived sovereign risk, heighten sensitivity to the interest-rate environment, and may reduce the scope for a predictable issuance policy. Research on the euro area indicates that high and increasing levels of public indebtedness may be associated with adverse macroeconomic effects and constraints on economic growth, particularly when debt reaches elevated levels (Checherita-Westphal & Rother, 2012). Under such conditions, a green bond can hardly serve as a substitute for fiscal credibility. It may form part of a better-structured debt-management strategy, but it cannot, by itself, compensate for a weakened budgetary position.

The reformed European economic governance framework similarly emphasises sustainable public finances and medium-term fiscal-structural plans. Regulation (EU) 2024/1263 explicitly connects the coordination of economic policies with the sustainability of public finances and the establishment of multiannual fiscal trajectories that reflect the specific debt-related challenges faced by individual Member States ([European Parliament & Council of the European Union, 2024](#)). This is important for green financing because climate-related investment requires a long-term perspective, while its debt financing must remain compatible with the issuer's sustainable fiscal position.

The green bond literature further supports this argument. Evidence concerning the existence of a greenium remains mixed and suggests that any pricing advantage associated with green bonds is limited and conditional. [Hachenberg and Schiereck \(2018\)](#) find that green bonds may trade at narrower spreads than comparable conventional bonds, although the effect depends on credit rating, sector, and issuer characteristics. [MacAskill et al. \(2021\)](#) demonstrate that empirical findings concerning the green premium differ between primary and secondary markets and are influenced by governance arrangements, reporting practices, and the quality of the green bond framework. Investor demand is therefore determined not only by the environmental purpose of the bond but also by the combination of green credibility and overall creditworthiness.

This is particularly relevant for sovereign issuers. A country with a stronger fiscal position is better able to maintain a regular and predictable issuance programme, provide more liquid benchmark bonds, and attract a broader base of institutional investors. A stronger fiscal balance may be interpreted as a signal of fiscal discipline and a lower probability that future green bond issues will be perceived as instruments intended to conceal fiscal pressure. Conversely, under a weaker fiscal position, a green bond issuance may be viewed primarily as additional public debt rather than as a credible component of a long-term sustainable-transition strategy.

Economic scale also remains relevant to market depth. Larger economies generally have a broader portfolio of eligible green public expenditure, more developed capital markets, larger borrowing programmes, and more established relationships with international investors. These factors facilitate not only initial market entry but also the subsequent accumulation of a substantial stock of green debt. Green debt market depth should therefore be understood as the outcome of the interaction between economic scale and fiscal credibility.

Accordingly, the present study assumes that the fiscal position is not necessarily a decisive prerequisite for initial market entry, but that it is an important determinant of subsequent market depth. Green bond markets develop more successfully where the green financing framework is supported by a stable debt-management policy, predictable budgetary governance, and sufficient economic scale. On this basis, the second hypothesis is formulated as follows:

H2. *Green debt market depth is greater in countries with larger economic scale and stronger general government budget balances.*

2.4. Environmental Taxation and Green Debt Instruments

Environmental taxes and green debt instruments constitute two distinct but interrelated mechanisms of green policy. Environmental taxes operate through price incentives: they increase the cost of activities that generate negative environmental externalities and encourage businesses and households to adopt lower-emission technologies, improve energy efficiency, and pursue more sustainable consumption patterns. This logic underpins the theory of environmental taxation and the debate concerning the so-called “double dividend”, according to which appropriately designed green taxes may simultaneously

reduce pollution and improve the structure of public revenues (Goulder, 1995). Within the European Union, this function is reflected in the framework governing the taxation of energy products and electricity, as well as in the broader policy architecture of carbon pricing (Council of the European Union, 2003; Haites, 2018).

The empirical literature provides evidence that environmental taxation and carbon pricing can influence the behaviour of economic agents and reduce emissions. Andersson (2019) demonstrates that the Swedish carbon tax led to a substantial reduction in emissions from transport fuels, while Best et al. (2020) find that countries with carbon-pricing mechanisms experienced lower growth rates of fossil-fuel-related emissions than countries without such instruments. At the same time, Metcalf and Stock (2020) find no robust evidence that carbon taxes adversely affect GDP growth or employment. Martin et al. (2014) similarly demonstrate that the United Kingdom's Climate Change Levy reduced energy intensity and electricity consumption in manufacturing without producing statistically significant adverse effects on employment, revenue, or plant exit.

Green bonds perform a different function. They do not directly alter the relative prices of polluting and environmentally sustainable activities but instead mobilise capital to finance predefined green investments. Whereas environmental taxation affects incentives, green bonds influence the availability, maturity structure, and visibility of financing. They are therefore particularly suitable for capital-intensive projects involving energy efficiency, renewable energy, clean transport, climate-change adaptation, and public green infrastructure (Sartzetakis, 2021). In this respect, green bonds constitute an instrument for financing the transition, whereas environmental taxation is an instrument for correcting economic incentives.

This distinction is important for the present study because it explains why the two instruments should not automatically be treated as substitutes. If environmental taxes and green bonds were functional substitutes, countries with a lower intensity of environmental taxation might be expected to compensate by developing deeper green debt markets. Conversely, countries with higher environmental taxes might be expected to have less need for green debt financing. Theoretically, however, such a relationship is not inevitable. Environmental taxation can generate both a price signal and public revenue, while green bonds can provide upfront financing for investments whose benefits materialise over a longer period.

Moreover, the two instruments may be complementary. Carbon or environmental pricing increases the relative return on low-carbon investment by making polluting alternatives more expensive. It may therefore strengthen the economic rationale of projects financed through green bonds. Campiglio (2016) emphasises that carbon pricing is important but may be insufficient in isolation when the financial system fails to direct adequate credit and capital towards low-carbon sectors. From this perspective, green debt financing may complement rather than replace fiscal incentives.

Direct evidence regarding the joint operation of these two instruments in the European Union is provided by Li et al. (2023), who examine the effects of green bonds and environmental taxes on energy efficiency across the 27 EU Member States. Their results indicate that green bonds accelerate improvements in energy efficiency, while environmental taxation also functions as a fiscal incentive encouraging energy-efficient behaviour. These findings support the view that green bonds and environmental taxes can operate simultaneously through different policy channels.

This distinction is particularly significant in the European context. Member States differ in the composition of their tax revenues, energy mixes, transport systems, industrial structures, and capacity to mobilise green finance. A country may have a relatively high share of environmental tax revenue because of the structure of its energy and transport taxes,

but this does not necessarily imply that it has a developed green bond market. Conversely, a country with a deeper green debt market may use bonds to finance investment without this necessarily implying either lower or higher environmental tax intensity. The European Green Bond Regulation establishes rules concerning transparency and the use of proceeds, but it neither replaces tax policy nor determines the national structure of environmental taxation (European Parliament & Council of the European Union, 2023).

Accordingly, the present study assumes that environmental taxes and green debt are distinct but potentially compatible instruments. Environmental taxes influence behaviour through prices and fiscal incentives, whereas green debt instruments mobilise capital for green investment. The absence of a strong negative relationship between them would therefore indicate that Member States do not necessarily choose between taxation and green debt but may employ both instruments in parallel as part of a broader sustainable-transition strategy. On this basis, the third hypothesis is formulated as follows:

H3. *Environmental taxation is not negatively associated with green debt market depth.*

3. Materials and Methods

3.1. Data and Sample

The analysis covers all 27 EU Member States. The unit of observation is the country–year. Data on green debt securities are obtained from the European Central Bank’s Securities Issues Statistics, compiled from the Centralised Securities Database (CSEC dataset, extracted in June 2026). The dataset reports outstanding amounts of green debt securities by issuing sector at nominal value (ECB, 2026).

The descriptive analysis uses monthly series covering the period from December 2020 to April 2026. The econometric analysis is based on annual year-end observations for the period 2021–2025, resulting in a balanced panel of 135 country–year observations.

The macroeconomic, fiscal, financial, and environmental variables are obtained from Eurostat. Government debt and the general government budget balance are drawn from the dataset Government deficit/surplus, debt and associated data (online data code: gov_10dd_edpt1; Eurostat, 2026d). The long-term interest rate is obtained from the EMU convergence criterion series—annual data (irt_lt_mcby_a; Eurostat, 2026b). Environmental tax revenue is taken from Environmental tax revenues (env_ac_tax; Eurostat, 2026c), while greenhouse gas emissions per capita are derived from Domestic net greenhouse gas emissions (sdg_13_10; Eurostat, 2026a). Gross domestic product is obtained from Gross domestic product at market prices (tec00001; Eurostat, 2026e).

All explanatory variables enter the models with a one-year lag. This choice reflects the temporal logic of issuance decisions, which generally respond to the macroeconomic and fiscal conditions prevailing before market entry or the expansion of outstanding green debt. Current market outcomes are therefore related to predetermined conditions, reducing the risk of simultaneity.

The lag structure is also consistent with Eurostat’s data-release calendar. At the time of the analysis, data on environmental tax revenue and greenhouse gas emissions for 2025 had not yet been published.

3.2. Variables

The present study considers market development along two dimensions: market entry and market depth.

Market entry indicates whether a country participates in the sovereign green bond market. It is measured using a binary indicator equal to one when the country has out-

standing sovereign green debt in the respective year and zero otherwise. This variable is used as the dependent variable in the Probit model.

Market depth captures the relative size of the green debt market within the national economy. It is measured as the total outstanding stock of green debt securities issued by all resident sectors, expressed as a percentage of GDP. This variable is used as the dependent variable in the Tobit model. Distinguishing between the two dimensions makes it possible to separate the decision to participate in the market from the degree of market development following participation.

The explanatory variables encompass economic, fiscal, financial, and environmental characteristics. The natural logarithm of GDP captures economic scale. Government debt as a percentage of GDP and the general government budget balance as a percentage of GDP represent the fiscal position. The long-term interest rate captures financing conditions. Environmental tax revenue as a percentage of GDP measures the intensity of green fiscal policy. Greenhouse gas emissions per capita capture the environmental profile of the economy.

In addition, the share of the outstanding green debt stock covered by a second-party opinion (SPO) is used as a supplementary indicator. In the descriptive analysis, it serves as a measure of the institutional and verification quality of the market. In the robustness analysis, it is used to construct an alternative dependent variable.

In the extended specifications, two additional variables are employed. Institutional quality is measured by the Government Effectiveness estimate from the Worldwide Governance Indicators (World Bank, 2025), which summarises perceptions of the quality of public services, the civil service, and policy formulation and implementation. Aggregate financial risk is measured by the annual average of the CBOE Volatility Index (VIX), obtained from the Federal Reserve Bank of St. Louis (2026). Like the other regressors, both variables enter the models with a one-year lag.

Table 1 presents the descriptive statistics.

Table 1. Descriptive statistics, 2021–2025.

Variable	N	Mean	Std. Dev.	Min	Median	Max
Green stock, % of GDP	135	3.23	3.36	0.00	1.96	13.84
ln GDP	135	12.43	1.41	9.72	12.52	15.31
SPO share, %	119	89.25	19.10	0.00	95.22	100.00
Government debt, % of GDP	135	66.80	35.95	18.40	57.80	197.30
Budget balance, % of GDP	135	−2.61	2.95	−9.30	−2.60	4.50
Long-term interest rate, %	135	2.76	1.73	−0.37	2.92	7.57
Environmental taxes, % of GDP	108	2.33	0.79	0.85	2.19	5.62
GHG emissions, t per capita	108	7.42	2.09	3.80	7.10	14.90
Government Effectiveness (WGI)	108	1.13	0.56	−0.08	1.12	2.19

Note: Contemporaneous descriptive statistics for the EU-27, 2021–2025 (maximum $n = 135$). Environmental taxes, GHG emissions, and Government Effectiveness are available through 2024. In the regression models, explanatory variables enter with a one-year lag, so values for 2020–2024 are matched to market outcomes for 2021–2025. The SPO share is defined only for observations with a positive green debt stock. Sources: ECB (2026); Eurostat (2026a, 2026b, 2026c, 2026d, 2026e); World Bank (2025).

The descriptive statistics reveal considerable heterogeneity in the sample. Environmental tax revenues range from 0.85% of GDP in Ireland to 5.62% in Greece, which also records the highest government debt in the sample (197.3% of GDP in 2021), while greenhouse gas emissions per capita vary almost fourfold, from 3.8 tonnes in Malta to 14.9 tonnes in Luxembourg. The dispersion of the green debt stock itself—a standard deviation exceeding its mean—provides a first indication of the uneven market development that motivates the analysis.

3.3. Empirical Strategy

The empirical strategy combines three mutually complementary methods.

3.3.1. Descriptive and Comparative Analysis

The descriptive analysis traces the development of the EU green debt market and its sectoral structure from December 2020 to April 2026. It also compares the depth of national markets at the end of 2025. The purpose is to demonstrate both the overall expansion of the market and the uneven participation of Member States. This provides the basis for distinguishing between market entry and market depth, on which the regression analysis is built.

3.3.2. Probit Model

The first dimension of market development is a country's participation as a sovereign green issuer. It is examined using a Probit model that estimates the probability that country i has outstanding sovereign green debt in year t :

$$\Pr(\text{Issuer}_{it} = 1) = \Phi(\beta'X_{i,t-1}), \quad (1)$$

where $X_{i,t-1}$ contains the explanatory variables lagged by one year and Φ denotes the standard normal cumulative distribution function. The results are reported as average marginal effects. Standard errors are clustered at the country level to account for potential serial correlation within individual countries. The number of clusters is 27.

3.3.3. Tobit Model

The second dimension of market development is market depth, measured as the outstanding green debt stock as a percentage of GDP. This dependent variable is equal to zero for country-year observations with no green debt, which account for 16 of the 135 observations. A Tobit model is therefore employed:

$$\text{GreenStock}_{it} = \max(0, \gamma'X_{i,t-1} + \varepsilon_{it}), \quad \varepsilon_{it} \sim N(0, \sigma^2), \quad (2)$$

where $X_{i,t-1}$ includes the explanatory variables lagged by one year and ε_{it} is the random error term.

For nonlinear models of this type, conventional cluster-robust variance estimates may be unreliable when the number of clusters is moderate. Standard errors are therefore calculated using a non-parametric bootstrap with 500 replications. Entire countries, rather than individual observations, are resampled in each replication, thereby preserving the panel structure of the data.

Country fixed effects are deliberately excluded for two reasons. First, the observation period is short ($T = 5$). In nonlinear models such as Probit and Tobit, including a separate fixed effect for each country may give rise to the incidental parameters problem and result in inconsistent estimates (Greene, 2004; Lancaster, 2000). Second, sovereign green issuer status changes very little within individual countries over the period examined. In the Probit model, country dummy variables would perfectly predict the outcome for a large proportion of the countries and, more generally, would absorb most of the cross-country variation that the study seeks to explain. Dependence among observations within the same country is addressed through country-clustered standard errors in the Probit model and country-level bootstrap standard errors in the Tobit model. The influence of time shocks common to all countries is examined by including year fixed effects in the robustness analysis.

The robustness of the results is assessed in several ways. The market-depth model is re-estimated with year fixed effects; after excluding the three largest markets; using an alternative dependent variable measuring the stock of green debt covered by a second-party opinion (SPO); separately for the subperiods 2021–2022 and 2023–2025; with an indicator for the pandemic-recovery years; with the one-year-lagged annual average of the VIX as a control for global financial risk; and with the Government Effectiveness indicator as a control for institutional quality. In addition, differences across country groups are examined through interaction terms. The stability of the estimates is also assessed by successively excluding one country at a time from the sample.

4. Results

4.1. Expansion of the EU Green Bond Market

The EU green bond market expanded substantially over the period under review. Figure 1 presents the monthly development of outstanding green debt securities issued by EU-27 residents, disaggregated by institutional sector. At the end of 2020, the total stock amounted to slightly less than EUR 300 billion. By April 2026, it had reached approximately EUR 1.29 trillion—an increase of more than fourfold in just over five years. The trend is remarkably persistent, with no visible interruption arising from the 2022 energy crisis or the subsequent tightening of monetary policy.

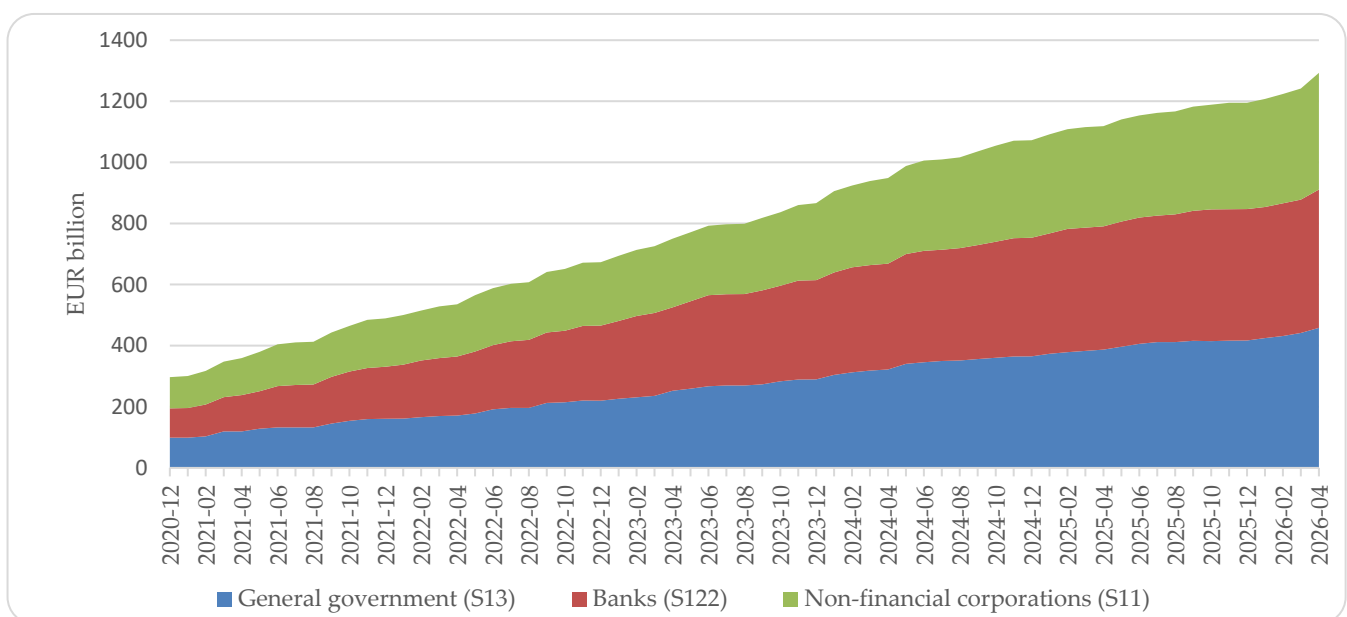


Figure 1. Outstanding green debt securities in the EU-27 by issuing sector, EUR billion (face value). Note: end-of-month outstanding amounts at face value, December 2020–April 2026. Source: authors' calculations based on ECB (2026).

The expansion encompasses all three issuing sectors. The general government segment increased from EUR 99 billion to EUR 458 billion, the outstanding stock issued by banks rose from EUR 96 billion to EUR 453 billion, and the non-financial corporate segment expanded somewhat more slowly, from EUR 102 billion to EUR 382 billion. Consequently, the market's sectoral structure remained balanced throughout the period. At the end of the observation window, general government and banks each accounted for approximately 35% of the outstanding stock, while non-financial corporations represented slightly less than 30%. No single sector dominates the market, indicating that green debt financing has become established in both the public and private segments of the European capital market.

Market growth also outpaced economic growth. Based on year-end values, the outstanding green debt stock increased from 3.3% of EU-27 GDP in 2021 to 6.4% in 2025. Over the same period, the number of Member States with a positive green debt stock increased from 22 to 26.

Taken together, these trends show that green bonds are no longer a niche instrument. Within half a decade, they became an important segment of European sustainable finance, directing capital towards the green transition through sovereign, bank, and corporate balance sheets alike.

4.2. Cross-Country Differences in Market Development

The overall expansion documented in the preceding section conceals substantial differences among Member States. Figure 2 ranks the EU-27 countries according to their total outstanding green debt relative to GDP at the end of 2025. The range is wide, extending from 13.8% of GDP in Sweden and 12.3% in Denmark to virtually zero in Bulgaria and 0.1% in Malta. The market is also highly concentrated in absolute terms: the five largest issuing countries account for approximately three quarters of the total outstanding green debt stock in the EU.

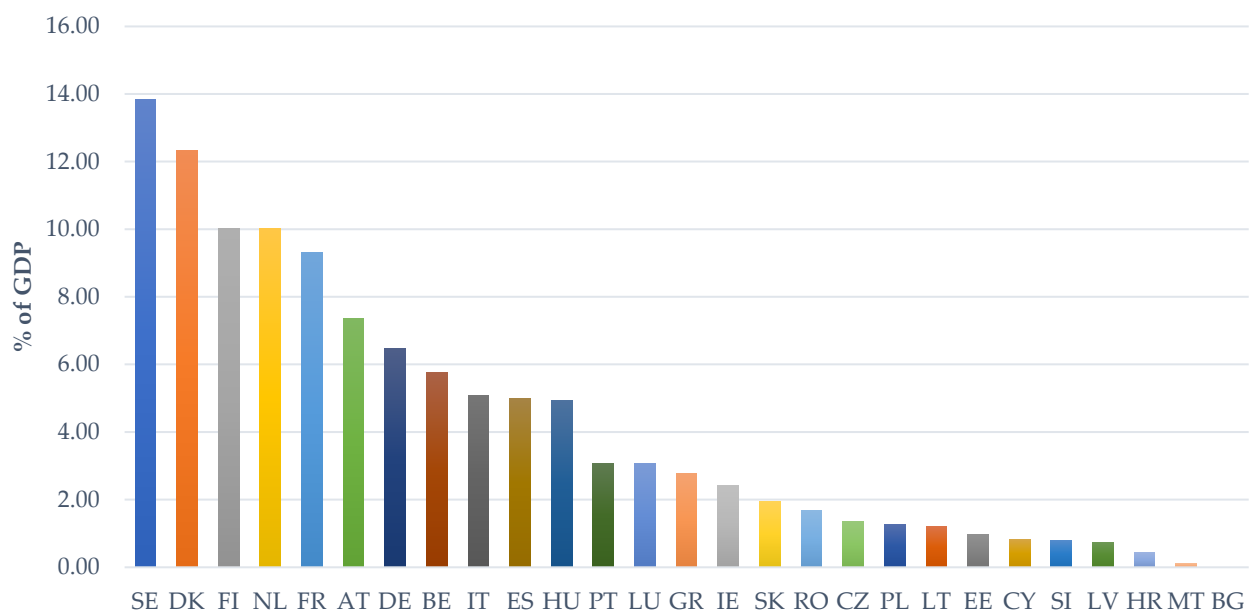


Figure 2. Total outstanding green debt as a percentage of GDP by EU Member State, end-2025. Note: Total outstanding green debt securities issued by all resident sectors as a percentage of GDP at the end of 2025. Source: authors' calculations based on ECB (2026) and Eurostat (2026e).

Three broad groups can be distinguished. The first comprises mature markets, including the Nordic countries, the Netherlands, France, Austria, and Germany, which maintain an outstanding green debt stock exceeding 6% of GDP. The second and larger group consists of countries in an intermediate position, including Belgium, Italy, Spain, and Hungary, as well as most issuers from Central and Eastern Europe. In these countries, the green debt stock ranges from approximately 1% to 6% of GDP. The third group—Bulgaria, Malta, Croatia, Latvia, Slovenia, Cyprus, and Estonia—remains on the market periphery, with outstanding stocks below 1% of GDP.

Figure 2 also shows that countries with sovereign green bond issuance generally have deeper markets, although the relationship is not absolute. Finland has an outstanding

green debt stock equivalent to 10% of GDP without having issued a single sovereign green bond, relying entirely on bank and corporate issuance. Conversely, Romania and Lithuania have already entered the sovereign segment, while the overall depth of their markets remains limited.

Importantly, these differences cannot be explained solely by the fiscal position. Sweden and Denmark combine low government debt with the deepest green markets in the Union. Bulgaria, however, has a similarly low debt level—approximately 30% of GDP—but no green debt market at all. The reverse comparison is equally revealing. Italy, with government debt close to 140% of GDP, is an active sovereign issuer and has a market above the EU median. Greece, by contrast, has a comparable debt burden but has not issued sovereign green debt.

This pattern indicates that fiscal space alone is neither a sufficient condition for market development nor an indispensable prerequisite. A multidimensional analysis is therefore required, simultaneously accounting for economic scale, the fiscal position, financing conditions, and green policy instruments.

4.3. Market Entry: Determinants of Sovereign Green Issuance

Table 2 reports the average marginal effects from the pooled Probit model. The dependent variable indicates whether a Member State has outstanding sovereign green debt in a given year. All explanatory variables enter the model with a one-year lag. Standard errors are clustered at the country level, and the model covers the full EU-27 panel for 2021–2025.

Table 2. Probit estimates, dependent variable: sovereign green issuer (0/1), 2021–2025, $n = 135$.

Variable ($t - 1$)	AME	Cluster-Robust SE	p -Value
ln GDP	0.243	0.026	0.000
Government debt, % of GDP	−0.004	0.002	0.119
Budget balance, % of GDP	−0.009	0.016	0.543
Long-term interest rate, %	−0.033	0.025	0.190
Environmental taxes, % of GDP	−0.056	0.063	0.370
GHG emissions, t per capita	−0.053	0.031	0.086
Observations/country clusters	135/27		
Issuer country-years/issuer countries (2025)	69/14		
Pseudo- R^2 /log-likelihood	0.483/−48.3		
Correctly classified, %	82.2		

Note: Average marginal effects from a pooled Probit model. All explanatory variables are lagged by one year. Standard errors are clustered by country. Classification accuracy is based on a 0.5 probability cut-off. Source: authors' calculations based on ECB and Eurostat data.

The results indicate that economic scale is the main factor associated with entry into the sovereign green bond market. The average marginal effect of log GDP is positive, substantial, and statistically significant. By contrast, government debt, the budget balance, and the long-term interest rate are not statistically significant. Environmental taxation is also not significantly associated with sovereign market entry.

Greenhouse gas emissions per capita have a weakly negative association with participation, which is statistically significant only at the 10% level. This suggests that countries with lower per capita emissions may be somewhat more likely to issue sovereign green debt. Given the limited statistical significance of this result, however, it should be interpreted cautiously.

The economic magnitude of the relationship with GDP is substantial. Model-based predictions show that, holding the other explanatory variables at their sample means, the

predicted probability of sovereign green bond market participation rises from approximately 9.2% for a country at the 25th percentile of the GDP distribution, with GDP of around EUR 80 billion, to approximately 87.4% for a country at the 75th percentile, with GDP of around EUR 590 billion. This represents a difference of roughly 78 percentage points and indicates that the economic size of a Member State is strongly associated with its predicted probability of entering the sovereign green bond market.

One possible interpretation is that sovereign green bond issuance requires a minimum effective scale. A sufficiently large and predictable borrowing programme is needed to support a liquid benchmark issue. Countries must also establish a green bond framework, identify eligible expenditure, and maintain credible reporting and external-review arrangements. These requirements involve fixed financial and administrative costs, which may weigh more heavily on smaller economies and borrowing programmes. Smaller Member States may therefore remain outside the sovereign segment not because they lack green financing needs, but because the relative costs of market entry are higher.

Overall, the results support H1: economic scale is positively associated with participation in the sovereign green bond market, while the current fiscal position has no statistically significant independent association with market entry.

4.4. Market Depth: Fiscal Position and the Outstanding Green Debt Stock

Table 3 reports the estimates from the pooled Tobit model. The dependent variable is the total outstanding stock of green debt securities as a percentage of GDP. The model accounts for 16 country–year observations with no outstanding green debt, for which the dependent variable is equal to zero. All explanatory variables enter the model with a one-year lag. Standard errors are obtained from a country-level bootstrap with 500 replications.

Table 3. Tobit estimates, dependent variable: total green stock, % of GDP, 2021–2025, $n = 135$ (16 censored).

Variable (t – 1)	Coefficient	Bootstrap SE	p-Value
ln GDP	1.730	0.423	0.000
Government debt, % of GDP	−0.009	0.017	0.597
Budget balance, % of GDP	0.411	0.138	0.003
Long-term interest rate, %	−0.197	0.174	0.258
Environmental taxes, % of GDP	−0.532	0.658	0.419
GHG emissions, t per capita	−0.448	0.310	0.148
Constant	−11.330	4.418	0.010
Observations/country clusters	135/27		
Censored observations	16		
Log-likelihood/ $\hat{\sigma}$	−291.5/2.47		
Bootstrap replications	500		

Note: Coefficients from a pooled Tobit model with left censoring at zero. All explanatory variables are lagged by one year. Bootstrap standard errors are based on 500 replications resampling countries as clusters. Source: authors' calculations based on ECB and Eurostat data.

Economic scale remains positively and statistically significantly associated with market depth. The coefficient on log GDP indicates that larger economies tend to have deeper green debt markets even when the outstanding stock is measured relative to GDP. The main difference from the market-entry model concerns the fiscal position. While the budget balance is not statistically significant in the Probit model, it is positively and significantly associated with market depth in the baseline Tobit specification. Government debt, the long-term interest rate, environmental taxation, and greenhouse gas emissions per capita are not statistically significant.

The economic magnitude of the relationship with the budget balance is also relevant. Model-based predictions indicate that, holding the other explanatory variables at their sample means, moving from the 25th percentile of the budget-balance distribution, approximately -4.65% of GDP, to the 75th percentile, approximately -0.90% of GDP, is associated with an increase in the predicted outstanding green debt stock from about 2.8% to about 4.2% of GDP. This difference of approximately 1.4 percentage points is substantial relative to the median market depth of 2.6% of GDP among countries with a positive green debt stock.

The contrast between the market-entry and market-depth results is central to the analysis. Fiscal conditions are not significantly associated with whether a country enters the sovereign green bond market, but the baseline estimates indicate that they are related to the extent to which the broader green debt market develops. One possible interpretation is that countries with stronger budgetary positions are better able to maintain regular issuance programmes, support liquid benchmark issues, and sustain investor confidence. However, this interpretation should not be regarded as evidence of a narrowly defined causal fiscal channel.

To examine whether the budget balance captures fiscal conditions specifically or broader issuer credibility, the model is re-estimated with the Government Effectiveness indicator as an additional control. Institutional quality is positively and statistically significantly associated with market depth, while the budget-balance coefficient becomes smaller and loses statistical significance. The coefficient on economic scale remains positive.

This comparison should be interpreted with caution. Government Effectiveness varies mainly across countries rather than over time during the short sample period, and it is positively correlated with the fiscal position. The model therefore cannot clearly separate the independent contribution of fiscal conditions from that of institutional quality. The results instead suggest that market depth is associated with issuer credibility in a broader sense, encompassing fiscal strength, administrative capacity, and effective public institutions.

In the corresponding Probit specification, Government Effectiveness is not statistically significant, while the association between economic scale and sovereign market entry remains robust.

Taken together, the baseline results support H2, but with an important qualification. Economic scale is robustly associated with market depth, whereas the positive relationship with the budget balance partly overlaps with broader institutional quality and should not be interpreted as an isolated causal fiscal effect.

4.5. Environmental Taxes and Green Debt: No Evidence of Substitution

If green debt financing operated as a substitute for environmental taxation, countries with lower environmental tax revenues would be expected to compensate by developing deeper green debt markets. This would imply a negative and statistically significant relationship between the two instruments. The baseline results do not support this proposition. Environmental tax revenues are not statistically significant in either the sovereign market-entry model reported in Table 2 or the market-depth model reported in Table 3.

Table 4 examines the robustness of this result across alternative specifications of the market-depth model. These include year fixed effects; the exclusion of Germany, France, and the Netherlands, which are the three largest markets in absolute terms; an alternative dependent variable based on green debt covered by a second-party opinion; separate estimates for 2021–2022 and 2023–2025; an indicator for the pandemic-recovery years; the lagged annual VIX as a control for global financial risk; and Government Effectiveness as a control for institutional quality.

Table 4. Robustness checks for green debt market depth: selected Tobit coefficients.

Specification	ln GDP	Budget Balance	Environmental Taxes	Government Debt
Baseline (Table 3)	1.730 *** (0.423)	0.411 *** (0.138)	−0.532 (0.658)	−0.009 (0.017)
With year fixed effects	1.732 *** (0.485)	0.260 (0.184)	−0.401 (0.748)	−0.015 (0.019)
Excluding DE, FR, NL	1.836 *** (0.613)	0.346 ** (0.149)	−0.810 (0.755)	−0.013 (0.023)
Dependent: SPO-verified stock only	1.767 *** (0.437)	0.345 ** (0.136)	−0.412 (0.672)	−0.014 (0.017)
Subperiod 2021–2022 (<i>n</i> = 54)	1.364 *** (0.367)	0.374 *** (0.133)	−0.382 (0.535)	−0.005 (0.013)
Subperiod 2023–2025 (<i>n</i> = 81)	1.874 *** (0.573)	0.168 (0.288)	−0.398 (1.050)	−0.021 (0.025)
With pandemic-period dummy (2021–2022)	1.752 *** (0.429)	0.300 * (0.157)	−0.442 (0.746)	−0.015 (0.020)
With lagged annual VIX	1.768 *** (0.498)	0.319 ** (0.149)	−0.507 (0.692)	−0.015 (0.019)
With institutional quality (WGI GE)	0.962 *** (0.339)	0.119 (0.099)	0.348 (0.449)	0.005 (0.013)

Selected coefficients from separate pooled Tobit models. Bootstrap standard errors are reported in parentheses and are based on 500 country-level replications. All baseline explanatory variables are lagged by one year. Additional-control coefficients are: Government Effectiveness, 5.363 (0.957); lagged VIX, −0.085 (0.044); and pandemic-period indicator, −1.411 (0.828). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Source: authors' calculations.

Across these specifications, the environmental-tax coefficient varies in magnitude and, in the institutional-quality specification, changes sign. It nevertheless remains statistically insignificant throughout. The analysis therefore provides no evidence of the negative relationship that would be expected if environmental taxation and green debt financing operated as substitutes. This result does not demonstrate that the two instruments are unrelated or complementary; it shows only that the available data do not support the substitution hypothesis.

The broader robustness results are generally consistent with the baseline estimates. The coefficient on economic scale remains positive across all specifications. The budget-balance coefficient also remains positive, although it becomes less precisely estimated in the shorter subperiods and decreases substantially when institutional quality is included. Controlling for the pandemic-recovery period and for global financial risk does not materially alter the main results.

The lagged VIX enters with a weakly negative coefficient. However, because the index varies only over time and the sample covers five years, this finding should be treated as suggestive rather than as evidence of a separately identified global-risk channel. In the corresponding pooled Probit models, the additional pandemic, VIX, and institutional-quality variables are not statistically significant, while the association between economic scale and sovereign market entry remains stable.

Taken together, the findings provide no evidence that Member States compensate for lower environmental tax revenues by developing deeper green debt markets. The results are consistent with the view that the two instruments perform different functions: environmental taxes influence behaviour through prices and incentives, whereas green bonds mobilise capital for green investment. However, the analysis does not directly establish that they are used jointly or that they are complementary.

The findings are therefore consistent with H3: no statistically significant negative association is found between environmental taxation and green debt market depth.

4.6. Heterogeneity in the Budget-Balance Relationship Across Country Groups

The association between the budget balance and green debt market depth may differ across groups of EU Member States. To examine this possibility, the pooled Tobit model is re-estimated on the full sample by adding, in turn, a group indicator and its interaction with the budget balance. This approach retains the full sample and avoids the substantial loss of observations and statistical precision that would result from estimating separate models for relatively small country groups. Table 5 presents the results for four classifications: euro-area membership, EU-15 membership, above-median government debt, and above-median economic size.

Table 5. Heterogeneity of the budget-balance effect: Tobit estimates with group interactions.

Grouping (D = 1 for)	Balance, D = 0	D × Balance	Balance, D = 1
Euro area	0.721 * (0.405)	−0.593 (0.439)	0.128 (0.173)
EU-15 member	0.075 (0.167)	−0.140 (0.264)	−0.065 (0.234)
Above-median debt	0.659 *** (0.238)	−0.650 ** (0.287)	0.009 (0.184)
Above-median GDP	0.121 (0.249)	0.405 (0.381)	0.526 ** (0.264)

Note: Separate pooled Tobit models with group interactions. Bootstrap standard errors are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Source: authors' calculations.

The results provide no statistically significant evidence that the budget-balance relationship differs between euro-area and non-euro-area countries or between EU-15 and other Member States. The interaction terms for these two classifications are not statistically significant. The baseline relationship therefore appears broadly similar across these groups, although the absence of statistical significance should not be interpreted as proof that the effects are identical.

The clearest difference concerns the level of government debt. Among countries with below-median debt, a stronger budget balance is positively and statistically significantly associated with market depth. For countries with above-median debt, the estimated relationship is close to zero. The interaction between high-debt status and the budget balance is negative and statistically significant, indicating that the association is weaker in more highly indebted countries.

The results for economic size point in the opposite direction. The estimated association between the budget balance and market depth is positive and statistically significant among above-median-GDP countries, whereas it is smaller and statistically insignificant among smaller economies. However, the interaction term itself is not statistically significant. The difference between the two groups should therefore be regarded as suggestive rather than conclusive.

Taken together, the results suggest that the relationship between the budget balance and green debt market depth is not uniform across all Member States. It appears strongest where the existing debt burden is relatively low and, more tentatively, among larger economies. One possible interpretation is that a favourable current budget balance provides a stronger signal of issuer credibility when it is not accompanied by an already elevated stock of public debt. Given the short period, the moderate number of countries, and the multiple comparisons, these findings should be interpreted cautiously.

4.7. Market Credibility and Robustness of the Results

The widespread use of second-party opinions provides an indication of the credibility and transparency of the EU green debt market. Among the observations for which SPO

data are available, close to 90% of the outstanding green debt stock is covered by external review on average (Table 1). This suggests that market expansion has been accompanied by the broad adoption of verification and disclosure practices, although the SPO share alone cannot capture all dimensions of market quality.

The alternative specifications reported in Table 4 broadly confirm the main findings. The positive association between economic scale and market development remains stable, while environmental taxation remains statistically insignificant throughout. The coefficient on the budget balance retains its positive sign in most specifications, although its magnitude and statistical precision decline when institutional quality is included. The results therefore suggest that the budget-balance relationship partly overlaps with broader issuer credibility.

The leave-one-country-out analysis provides an additional check that the estimates are not determined by a single Member State. When each of the 27 countries is excluded in turn, the Tobit coefficient on log GDP ranges from 1.59 to 2.05, while the budget-balance coefficient remains positive and ranges from 0.26 to 0.44. In the pooled Probit model, the average marginal effect of log GDP varies only between 0.23 and 0.28. These relatively narrow ranges indicate that the principal results are not driven by any individual country.

5. Discussion

5.1. Market Scale as a Barrier to Entry

The dominant role of economic scale indicates that sovereign green bond market entry is not merely an expression of political will or climate ambition. It also depends on structural characteristics accumulated over time, including the depth and liquidity of the government securities market, an established investor base, and institutional debt-management capacity. This is consistent with evidence that economic scale, institutional factors, and the investor base shape government bond markets (Burger et al., 2012; Claessens et al., 2007).

For sovereign green bonds, these general market conditions carry additional weight. A green issue must be sufficiently large to be recognisable and liquid for institutional investors, while also fitting within the country's overall debt strategy. Larger economies can more readily integrate a green benchmark issue into their regular issuance calendar without disrupting the maturity structure or liquidity management. In smaller countries, a comparable issue may represent a disproportionate share of the annual financing programme, increasing the risk that it remains a one-off transaction rather than part of a consistent market strategy.

Fixed market-entry costs constitute an important part of this mechanism. Before entering the market, a sovereign issuer must establish a green bond framework, identify eligible expenditure, develop internal procedures for tracking proceeds, prepare pre-issuance information for investors, and arrange subsequent allocation and impact reporting. The European Green Bond Standard further institutionalises this logic through requirements concerning transparency, Taxonomy alignment, and external review (European Parliament & Council of the European Union, 2023). These requirements strengthen confidence but impose a higher relative cost on smaller issuers.

Economic scale should therefore be understood as more than GDP alone. It also captures the capacity for regular issuance, a sufficiently large portfolio of eligible green expenditure, market liquidity, and communication with international investors. EU evidence similarly links green bond issuance to countries' macroeconomic, financial, and governance characteristics (Dan & Tiron-Tudor, 2021), as well as to institutional quality, capital-market development, and climate commitments (Tolliver et al., 2020).

The importance of confidence further reinforces the barrier facing smaller issuers. Investors assess green bonds not only according to their environmental purpose but also according to information quality, issuer characteristics, and the presence of external verifi-

cation. [Bachelet et al. \(2019\)](#) show that green bond premia and liquidity depend on issuer type and third-party verification, while [Fatica et al. \(2021\)](#) find that pricing advantages vary across issuer groups and are associated with the quality of market participation. For smaller sovereign issuers, market entry therefore requires not only green projects but also an infrastructure of trust.

The European Union provides a common regulatory framework, but it does not fully eliminate national differences. The Capital Markets Union action plan emphasises the need for a more integrated single capital market capable of facilitating the mobilisation of private funds for sustainable investment ([European Commission, 2020](#)). Nevertheless, the practical capacity to use capital markets continues to differ among Member States. Common standards reduce information fragmentation but do not eliminate differences in scale, liquidity, administrative resources, and project readiness.

The absence of smaller Member States from the sovereign green bond market should therefore not automatically be interpreted as a lack of environmental ambition. It may reflect issuance economics and the relatively higher costs of preparation, certification, reporting, and communication. Some countries may finance green investment through European funds, bank intermediation, corporate issuance, or conventional government debt without creating a separate sovereign green bond programme. This distinction is important because it prevents market presence from being mechanically equated with climate ambition.

The policy implication is that equal access to green debt financing requires more than harmonised standards. Instruments are needed to reduce the fixed costs faced by smaller issuers: technical assistance for preparing green bond frameworks, standardised reporting templates, common methodologies for identifying eligible expenditure, support for external verification, and better coordination among budget authorities, debt-management offices, and institutions responsible for planning green investment. Solutions may also involve common European platforms, supranational channels, or the pooling of project portfolios when an individual issue is too small to be liquid.

The findings for H1 therefore support a more nuanced view of market entry. Economic scale summarises several structural preconditions: it reduces the relative burden of fixed costs, increases the likelihood of a liquid issue, and supports investor confidence. Once a country enters the market, however, the relevant question shifts from access to the depth and durability of market development, where fiscal credibility may play a greater role.

5.2. Green Bonds and Fiscal Sustainability

The contrast between market entry and market depth is one of the central findings of the study. Sovereign market participation is associated primarily with economic scale, whereas the baseline estimates link deeper green debt markets to both economic scale and a stronger budget balance. This suggests that fiscal conditions may matter more for the subsequent development of the market than for initial entry. Green bonds should therefore not be viewed as an alternative to sound fiscal management, although the results do not establish a separate causal fiscal channel.

This interpretation is consistent with the classical understanding of fiscal sustainability. [Bohn \(1998\)](#) evaluates sustainable fiscal policy through a government's capacity to respond to rising debt by improving the primary balance. From this perspective, the budget balance is not merely an accounting outcome for a particular year but a signal of the government's ability to maintain predictable debt dynamics. For the green bond market, this signal is particularly important because investors purchase a debt instrument, not merely an environmental objective. The green label may therefore enhance issuer visibility and attract sustainability-oriented investors, but it does not remove the assessment of credit risk.

The extended estimates qualify this interpretation. When Government Effectiveness is included in the market-depth model, institutional quality is positively and significantly associated with market depth, while the budget-balance coefficient becomes smaller and loses statistical significance. This does not imply that fiscal conditions are irrelevant. Rather, it suggests that the short panel cannot clearly separate their contribution from that of broader institutional capacity. Fiscal strength and effective public administration tend to coexist across EU Member States and may jointly support the ability to maintain regular issuance, transparent reporting, and credible external verification. The relevant concept of issuer credibility is therefore broader than the budget balance alone.

The sovereign-risk literature confirms that markets respond to fiscal fundamentals, particularly when uncertainty increases. [Schuknecht et al. \(2009\)](#) show that government risk premia are sensitive to the fiscal position and institutional environment. [Arghyrou and Kontonikas \(2012\)](#), [Beirne and Fratzscher \(2013\)](#), and [De Grauwe and Ji \(2013\)](#) further emphasise that the market pricing of sovereign risk in the euro area is influenced not only by debt and budget indicators but also by expectations, liquidity, and contagion risk. This is important for interpreting the present results: even when an issue has a clearly defined green purpose, investors remain sensitive to the issuer's overall credibility.

For green bonds, fiscal credibility is reinforced by the need for regularity and trust. A deep market requires recurring issuance, adequate volumes and liquidity, high-quality reporting, and a clear link between green expenditure and budget planning. Stronger fiscal positions may help sustain such programmes by combining climate investment with a predictable debt trajectory. Under fiscal pressure, by contrast, investors may view a green issue as additional debt rather than as part of a durable transition strategy.

The reformed European economic governance framework confirms this logic. Regulation (EU) 2024/1263 emphasises medium-term fiscal-structural plans, sustainable public finances, and the combination of fiscal adjustment with reforms and investment ([European Parliament & Council of the European Union, 2024](#)). In this context, green bonds can provide a useful instrument for financing climate and environmental priorities, but only when they are compatible with the medium-term budgetary trajectory. They should not be treated as an off-budget or parallel channel for circumventing fiscal constraints, but as part of a broader sustainable public-finance strategy.

This distinction is also important because of the growing link between climate risks and sovereign creditworthiness. [Beirne et al. \(2021\)](#) show that climate vulnerability may increase sovereign borrowing costs, while [Klusak et al. \(2023\)](#) find that climate change may affect sovereign credit ratings. From this perspective, green bonds have the potential to finance investment that reduces future climate and fiscal risks. This potential is realised, however, only when issuance is linked to genuine projects, credible reporting, and a sustainable fiscal framework. Otherwise, green debt may increase gross indebtedness without materially improving the sustainability of public finances.

The legal and financial literature also cautions against an excessively optimistic interpretation of sustainable debt instruments. [Lupo-Pasini \(2022\)](#) stresses that contractual mechanisms alone cannot resolve the public-governance and fiscal-sustainability challenges associated with sovereign debt. [Bolton et al. \(2022\)](#) situate the relationship between environmental protection and sovereign debt within the broader context of debt distress and the need for institutional solutions. These arguments support the conclusion that green bonds should not be regarded as an automatic mechanism of fiscal relief. They may improve the quality and targeting of financing, but they do not remove the need for credible debt policy.

From a policy perspective, deeper green debt markets require sustainable finance and fiscal responsibility to advance together. Governments should not expect the green label alone to lower financing costs or secure a permanently broader investor base. A more

realistic strategy is to align durable green-finance frameworks with medium-term budget planning, transparent project selection, and regular allocation and impact reporting.

The principal conclusion from H2 is therefore more nuanced. Economic scale is robustly associated with market depth, while the positive baseline relationship with the budget balance appears to form part of a broader credibility environment that also includes institutional capacity. Green bonds may broaden the public-finance toolkit and improve the visibility of climate investment, but their successful development requires credible fiscal management, effective institutions, and transparent reporting.

5.3. *Environmental Taxes and Green Debt: Distinct Policy Functions and No Evidence of Substitution*

The findings concerning H3 indicate that environmental taxation is not significantly negatively associated with green debt market depth. This absence of a robust statistical relationship should not be interpreted as evidence that the two instruments are interchangeable. Rather, it is consistent with their different functional logics: environmental taxation affects relative prices and the behaviour of economic agents, whereas green bonds provide earmarked financing for investments that often require substantial upfront capital and generate impacts over a long horizon.

This finding is consistent with the policy-mix literature. Flanagan et al. (2011) argue that different policies should not be examined in isolation, but through the interactions, interdependencies, and potential tensions among them. Rogge and Reichardt (2016) develop this logic in the context of sustainability transitions, emphasising the need to combine instruments, processes, and policy characteristics, including consistency, coherence, and credibility. From this perspective, the absence of a simple linear relationship between environmental taxes and green debt is to be expected: the two instruments form part of a broader policy mix rather than alternative channels for achieving the same objective.

The theoretical argument is further strengthened by the dual nature of market failures in the green transition. Jaffe et al. (2005) show that environmental externalities interact with market failures related to innovation and the diffusion of new technologies. A price signal alone is therefore rarely sufficient. Environmental taxes can correct some negative externalities, but they do not automatically guarantee adequate financing, technological readiness, or project capacity. Green bonds can address precisely this investment dimension of the transition.

Models of directed technological change point in the same direction. Acemoglu et al. (2012) show that optimal climate policy is not limited to carbon taxation but also includes measures that direct innovation towards clean technologies. Popp (2002) provides empirical evidence that energy prices can stimulate innovation in energy efficiency. These findings support the interpretation that environmental taxes are important for creating incentives, while the investment implementation of the transition requires additional financial instruments.

Green bonds address this investment dimension. Although they do not directly change price incentives, they can translate policy and technological priorities into investable project portfolios, especially where social benefits are high and returns are long term or partly external to individual investors. They may therefore finance part of the investment response encouraged by environmental taxation rather than compete with it.

The complementarity argument is also supported by research on the limitations of stand-alone carbon pricing. Bertram et al. (2015) show that climate objectives may remain achievable through a combination of carbon prices, technology policies, and energy measures. Campiglio (2016) likewise emphasises that price-based instruments should be supported by financial and banking mechanisms that direct capital towards low-carbon activities. The present findings are consistent with the view that tax policy and capi-

tal financing operate through different channels, although the absence of a significant association does not itself prove complementarity.

This distinction is particularly important in the European context. Directive 2003/96/EC establishes a framework for the taxation of energy products and electricity, while Regulation (EU) 2023/2631 governs European Green Bonds and the requirements concerning disclosure, the use of proceeds, and external review. These constitute two different regulatory layers. The first concerns price signals and fiscal revenues, while the second concerns the transparency and credibility of sustainable debt financing. Their different institutional purposes explain why they do not automatically substitute for one another.

The practical implication is that Member States need not treat environmental taxation and green debt as mutually exclusive alternatives. A more effective approach may be to establish a coherent policy mix in which environmental taxes guide behaviour and generate part of the public resources required, while green bonds mobilise additional capital for projects involving energy, transport, buildings, adaptation, and public infrastructure. This is particularly important for countries with limited fiscal capacity, as tax revenues alone are unlikely to finance the full investment requirements of the transition.

At the same time, the parallel use of these instruments requires coordination. If environmental tax revenues are used without reference to strategic investment needs, while green bonds are issued without a clear link to budget planning, the two instruments may remain administratively separate, reducing their effectiveness. Policy should therefore integrate tax incentives, project selection, green budgeting, and debt strategy within a common framework for the sustainable transition.

The conclusion from H3 is limited but policy-relevant. The analysis provides no evidence that environmental taxation substitutes for green debt market depth. This is consistent with the instruments' distinct functions: taxes create incentives and correct externalities, while green bonds finance and increase the visibility of green investment. The result does not, however, establish complementarity.

5.4. Implications for Smaller and Peripheral EU Economies

The findings are particularly relevant to smaller and peripheral EU economies. Limited participation in the green bond market should not automatically be interpreted as weak environmental ambition or fiscal performance. Some countries with low debt and comparatively stable budgets still lack an active sovereign green debt market, pointing to structural and institutional barriers to entry.

The first group of barriers concerns economies of scale. Smaller countries generally have more limited annual borrowing programmes, narrower secondary markets for government securities, and a smaller institutional investor base. For such countries, a stand-alone sovereign green issue may be too small to be liquid or too large relative to the conventional borrowing programme. This creates a risk that the green bond remains a one-off instrument rather than the beginning of a predictable sovereign green financing curve.

The second group of barriers arises from administrative and project capacity. A green bond requires not only an issuance decision but also prior work to identify eligible expenditure, ensure Taxonomy alignment, track proceeds, arrange external review, and report subsequent impacts. The European Green Bond Standard increases market quality and credibility but also strengthens the need for institutional preparation (European Parliament & Council of the European Union, 2023). For smaller issuers, these requirements impose a higher relative cost because the fixed expenses associated with the framework, methodology, and verification are spread across a smaller volume of issuance.

The third barrier concerns the development of a project portfolio. Smaller and peripheral economies often have substantial investment needs in energy efficiency, transport,

water infrastructure, climate-change adaptation, and public buildings, but these projects may be fragmented across different administrations, municipalities, and public enterprises. This makes it more difficult to assemble a sufficiently large, clearly defined, and verifiable portfolio of eligible green expenditure. The challenge therefore lies not only in the existence of investment needs but also in the capacity to convert them into a structured debt product.

In this context, national development banks and public investment banks can perform a key intermediary function. The literature regards them not only as instruments for correcting market failures, but also as institutions capable of creating and shaping markets, assuming early-stage risks, and mobilising private capital towards strategic objectives (Mazzucato & Penna, 2016). Geddes et al. (2018) show that state investment banks can support low-carbon finance through several roles, including risk reduction, project aggregation, the provision of long-term capital, and confidence building. The role of the European Investment Bank and national development banks as part of a broader European investment infrastructure is also relevant to the EU context (Mertens & Thiemann, 2019).

For smaller economies, green bond market development may therefore begin with institutional preparation rather than sovereign issuance. Priorities include a green-budgeting system, a project register linking expenditure to expected environmental effects, and a standardised framework that can be used by the government, municipalities, public enterprises, or national promotional institutions.

European instruments can reduce these barriers. Regulation (EU) 2021/240 established the Technical Support Instrument, which enables expertise to be provided to Member States for institutional, administrative, and structural reforms (European Parliament & Council of the European Union, 2021a). This makes it an appropriate channel for assisting smaller issuers in developing green-finance frameworks, project-selection methodologies, and reporting systems. The InvestEU Programme, established by Regulation (EU) 2021/523, uses an EU budget guarantee to support investment operations and mobilise additional public and private capital (European Parliament & Council of the European Union, 2021b). Regulation (EU) 2021/1058 on the European Regional Development Fund and the Cohesion Fund is important for less-developed regions because it links cohesion financing to investment objectives, including a greener, low-carbon Europe (European Parliament & Council of the European Union, 2021c).

These instruments do not replace the green bond market, but they can create the conditions for its development. Technical assistance can reduce market-entry costs, InvestEU can provide guarantee and advisory infrastructure, and cohesion funds can support the preparation of investment portfolios. Blended solutions are also possible, combining European funds, national development banks, and market financing within common project platforms. The small scale of individual projects can thus be overcome through aggregation and standardisation.

Support for smaller and peripheral countries should therefore focus less on one-off issues and more on durable infrastructure: green budgeting, coordination between finance ministries and sectoral authorities, project registers, standardised impact indicators, external-review procedures, and regular investor communication. Without this foundation, a sovereign green bond may be visible but have limited systemic effect.

For smaller and peripheral EU economies, the central task is to reduce fixed costs, strengthen administrative capacity, and use European support mechanisms to aggregate and standardise projects. These conditions would make the green debt market more inclusive and improve access where transition investment needs are substantial, but market infrastructure remains underdeveloped.

6. Conclusions

This article examines EU-27 green bond markets by distinguishing sovereign market entry from the depth of the overall green debt market. Outstanding green debt increased more than fourfold between the end of 2020 and spring 2026 across sovereign, bank, and corporate issuers. Development nevertheless remains highly uneven: a small group of Member States holds most of the outstanding stock, while several countries remain at the market periphery or outside it.

The econometric results show that market entry and market depth are associated with different factors. Sovereign market participation is related primarily to economic scale, while government debt and the budget balance are not significantly associated with entry. Market depth, by contrast, is positively associated with economic scale and, in the baseline specification, with a stronger general government budget balance. However, when Government Effectiveness is included, the budget-balance coefficient becomes smaller and loses statistical significance. The evidence therefore does not identify a separate causal fiscal channel. Instead, it suggests that fiscal conditions form part of a broader issuer-credibility environment that also includes institutional quality and administrative capacity.

Environmental taxation is not significantly associated with green debt market depth in either the baseline or the alternative specifications. The analysis therefore provides no evidence that Member States compensate for lower environmental tax revenues by developing deeper green debt markets. This finding does not establish that the two instruments are complementary or entirely independent; it indicates only that the available data do not support the substitution hypothesis.

The main policy implication is that uneven market development cannot be explained solely by fiscal discipline or environmental ambition. Economic scale, market infrastructure, and institutional capacity are particularly important. Smaller Member States face proportionately higher costs in establishing frameworks, identifying eligible expenditure, arranging external review, and maintaining regular issuance and reporting. EU support can promote a more inclusive market by reducing these costs, strengthening administrative capacity, and facilitating project aggregation and standardisation.

The study has several limitations. First, the econometric panel is short because harmonised CSEC data are available only from the end of 2020. The analysis therefore covers five annual observations for each of the 27 Member States and estimates with borderline statistical significance should be interpreted cautiously. Second, the models identify associations rather than causal effects. Lagging the explanatory variables reduces concerns about simultaneity but does not eliminate omitted-variable bias. Fiscal conditions, institutional quality, capital-market development, investor demand, and the availability of eligible green expenditure may be jointly related to market development. Moreover, institutional quality varies mainly across countries during the short sample period, making it difficult to separate its contribution from that of the fiscal variables. Third, the analysis is conducted at the country level and focuses on outstanding market volumes rather than individual issuance decisions, bond pricing, or secondary-market liquidity.

As longer data series become available, future research could examine the persistence of market entry and depth using richer panel methods. Issue- and issuer-level data would help identify the mechanisms underlying the country-level relationships documented here. Further research could also investigate whether fiscal and institutional credibility affect issuance costs, investor demand, and the size of any green premium.

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